Spolia Runiana.—I. *Funiculina quadrangularis* (Pallas) and the Hebridean *Diazona violacea*, Savigny.

By W. A. Herdman, F.R.S., F.L.S., Professor of Zoology in the University of Liverpool.

(Plates **13** & **14** and 2 Text-figures.)

[Read 5th December, 1912.]

The main part of our scientific work on board the yacht 'Runa' is planktonic and consists of surface and mid-water horizontal and also of vertical hauls from the deep fjords on the west coast of Scotland. The results of these plankton gatherings are reported on in detail elsewhere *.

The fish-trawl and the naturalist's dredge, are, however, also used from the yacht as often as can be managed, and I should like occasionally to make known to the Linnean Society any "Spolia Runiana" of special interest or novelty that may be brought up from the sea-bottom during our cruises.

In the past summer we spent about a month (August 1912) cruising on the west of Scotland, both amongst the inner islands (Mull, Skye, &c.) and also along the chain of the Outer Hebrides from Barra Head to Stornoway, dredging and townetting almost daily. Two of the more interesting animals obtained—the only ones I shall refer to in this communication—were the giant sea-pen *Funiculina quadrangularis* (Pallas) and the Compound Ascidian *Diazona violacea*, Savigny, first described from the Hebrides by Forbes and Goodsir under the name "*Syntethys hebridicus*," in 1851.†

(1) Funiculina quadrangularis (*Pallas*).

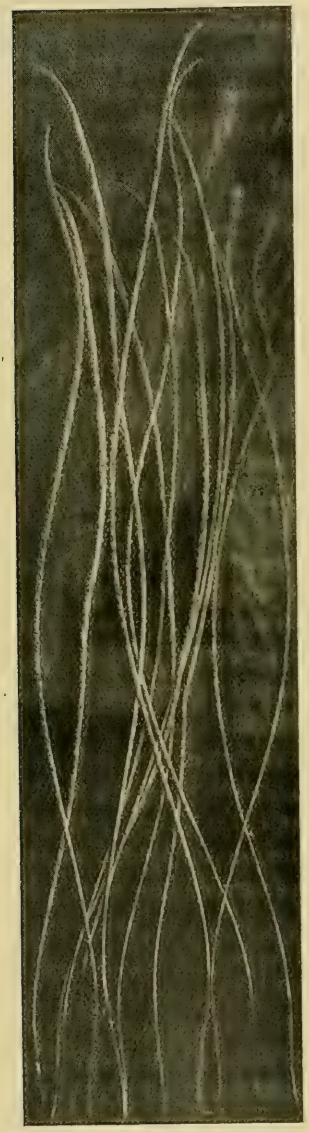
The late Professor A. Milnes Marshall and his father, Mr. W. P. Marshall, in their little book entitled 'Report on the Oban Pennatulida' (Birmingham, 1882), gave a detailed account of this "rare and interesting species," and of the circumstances under which it was dredged, in 1881, by members of the Birmingham Natural History Society at two localities in the Firth of Lorn, between Oban and the island of Lismore. It is rather surprising to read that on that occasion only four living specimens and three of the calcareous skeletons were obtained, and that the largest was only 39 inches in length, since we on the 'Runa' this summer brought up a score or more of larger specimens in every haul of the dredge, at that spot, along with very many smaller ones which were thrown back into the sea. Our largest specimen is

* Lancashire Sea-Fisheries Laboratory Annual Report for 1912.

† See Addendum, p. 171, with lists of Amphipods and Echinoderms.

now, in its preserved state, 62 inches in length, several others are about 5 feet, and we obtained a good many (at least 20) of 4 feet or a little over.

Fig. 1.



Funiculina quadrangularis (Pallas), from a photograph.

The Marshalls describe the upper part of the colony as being "of an ivory-white colour," but note that both Forbes and Wyville Thomson had recorded it as being "rose-coloured." Our specimens when alive were certainly of a pale translucent rosy tint, and a few colonies that I preserved in a 10 per cent. solution of formol in sea-water have still (after four months) the same beautiful colour and life-like appearance, while those put into alcohol have become opaque and vary from a creamy-white to yellowish-brown. Fig. 1 shows a group of these preserved specimens.

The first British specimens were apparently dredged in 1844, at this same locality, by Mr. R. McAndrew from his yacht, and were described by Prof. Edward Forbes in the 'Annals and Magazine of Natural History' (vol. xiv.). Sir Wyville Thomson, in 'The Depths of the Sea,' records having dredged "Pavonariæ" (=*Funiculina*) from 100 fathoms in Raasay Sound, and refers to their "pale lilac phosphorescence." He remarks further that from the number of specimens brought up at one haul "we had evidently passed over a forest of them"; and that is exactly the impression that was produced upon myself and upon my friend Mr. A. O. Walker, F.L.S., who was with me when we brought up such quantities of living colonies in the Firth of Lorn last August. It is probable that in our hauls from the 'Runa' we dredged through the thickest of the plantation, while the Birmingham naturalists in 1881 may possibly only have skirted along its edge. I may add that in our hauls most of the larger specimens were not actually in the trawl-net (which contained quantities of fine mud), but were balanced across the front of the frame (a 6-foot Agassiz trawl), and especially in a large bunch at each end, in such a precarious position that I had to go off in a punt and pick them out by hand before allowing the net to be raised above the

surface—and one wondered how many still finer specimens had dropped off in coming up through the water.

I can agree with the Marshalls' remark: "Not only is the geographical distribution of *Funiculina* a very limited one, but wherever it does occur it seems to be confined to a very small spot, in which it occurs fairly abundantly"—although I do not doubt that other localities will yet be discovered on the west coast of Scotland containing virgin forests of this largest and stateliest of the British Cœlenterata.

(2) Diazona violacea, Savigny.

This well-known Mediterranean Tunicate was described and figured by Savigny in 1816, and the genus *Diazona* was placed by him in the "Téthyes composées," immediately after *Clavelina*: both in description and figure the colour is given as a beautiful violet. Other notable characters in the original description are: the branchial and atrial apertures both 6-rayed, the internal longitudinal bars of the branchial sac provided with papillæ, and the meshes of the branchial sac containing each four stigmata. As we shall see, the latter two characters require some qualification. The first British specimen was found over sixty years ago by Edward Forbes and John Goodsir, in 30 fathoms of water, off the Croulin Islands, near Skye, and was described by them as a new genus and species under the name *Syntethys hebridicus* in the 'Transactions of the Royal Society of Edinburgh' for 1851 (vol. xx. p. 307). In this paper, Forbes and Goodsir tell how they were at the time on a yachting cruise "with our indefatigable friend Mr. McAndrew* among the Hebrides, in the month of August, 1850"; and in describing their discoveries they go on to say—"the most remarkable of them is the largest of Compound Ascidians yet discovered in the Atlantic. Its nearest described ally is the genus *Diazona* of Savigny, between which animal and *Clavelina* it constitutes a link; one of considerable zoological importance"—and more to the same effect, showing that Forbes and Goodsir had compared "*Syntethys*" with *Diazona* and regarded it as generically distinct. They point out that their "remarkable animal" is of an apple-green hue, that the branchial and atrial apertures are not lobed (although the atrial has six white ocelli), that the ascidiozooids have a sessile abdomen and are marked by lines of white pigment, that the branchial sac has 13 rows of stigmata, hooked fleshy tubercles at the angles of the meshes, and only one of the stigmata in each mesh. Forbes and Goodsir give a coloured figure of their colony, from which my fig. 2, on Pl. **13**, is copied, to give some idea of the distinctly green colour of the living animal. It is, however, in this figure,

* Mr. Robert McAndrew was a Liverpool merchant who owned the yacht 'Naiad,' a 70-ton yawl, which he made good scientific use of on dredging expeditions, chiefly in the interests of conchology.

not sufficiently delicate in its shades and is not sufficiently gelatinous and translucent in appearance.

Alder *, in 1863, described a specimen from the Channel Islands which seemed to bridge the gap between *Diazona* and *Syntethys* so effectually that he placed Forbes and Goodsir's species under Savigny's genus as *Diazona hebridica*, and he showed, moreover, that the living apple-green colour of his Guernsey specimen changed to violet on preservation in alcohol. The apertures of his specimen were obscurely 6-lobed, and consequently many subsequent writers have considered all these specimens to be the same species of *Diazona*, and the name "*hebridica*" has dropped out of use. The animal has since been found repeatedly in the Mediterranean (at Naples and elsewhere), off the coasts of Brittany, and near Plymouth. Garstang †, in 1891, pointed out some differences in detail between specimens from Plymouth and the description given by Forbes and Goodsir, and suggested the possible specific distinctness of the Hebridean form (*D. hebridica*) from all the rest (*D. violacea*). He concludes with the remark: "the whole matter is so beset with doubts that it is greatly to be desired that specimens should be obtained again from the Hebrides, and their anatomy re-described." Following upon this I published ‡ a brief note upon a Hebridean *Diazona* dredged off the north coast of Mull by the late Duke of Argyll, and sent to me for identification through Sir John Murray. I showed in this paper that all the supposed points of difference between the Mediterranean *Diazona* and the Hebridean *Syntethys* can be bridged over by examining in detail a sufficient number of ascidiozooids. Neither in the lobing of the apertures nor in the minute anatomy of the branchial sac can any constant character be found which will enable us to divide the specimens I have examined into two sets, "*hebridica*" and "*violacea*." The question of colour I shall return to below.

In recent systematic works on the Tunicata, such as Bronn's 'Thier-reich' (1909), and 'The British Tunicata,' by Alder and Hancock (Ray Society, 1912), *Syntethys hebridicus* has been accepted as a synonym of *Diazona violacea*, but probably without any further examination of Hebridean specimens.

Now we turn to the new material. While dredging from the 'Runa' this summer, specimens of *Diazona* closely resembling Forbes and Goodsir's *Syntethys* were found, as follows:—

(1) August 7th, a few miles south of Barra Head, in the Atlantic, 60 fathoms, one large colony measuring $9\frac{1}{2} \times 7\frac{1}{2} \times 5$ inches, and of a beautiful translucent pale green colour.

* Ann. & Mag. Nat. Hist. (3) xi. p. 169.
† Journ. Mar. Biol. Assoc. for May 1891, p. 47.
‡ Ann. & Mag. Nat. Hist. for Aug. 1891, p. 165.

(2) August 12th, on East Shiant Bank, in the Minch, north-east of Skye, 27 fathoms ; some smaller pieces, also pale green.

Fig. 1 on Pl. **13** is reproduced (half-size) from a water-colour sketch of the largest 'Runa' colony when alive, made by my wife on the yacht, and I give, for comparison, in fig. 2 a copy of the original illustration in Forbes and Goodsir's paper—both figures showing the green colour of life.

One of the smaller pieces obtained this summer was preserved in formalin, and it is still of the same pale transparent green hue as when alive. Another fragment was preserved in alcohol, and it has become of a pale purple or mauve tint, such as is shown in the little rectangle labelled A on Pl. **13**. The largest colony was placed in a tank of methylated spirit and shut up until the end of the cruise. On opening the tank a month later it was found that the spirit was stained a rich green and the Tunicate colony was now of a well-marked violet colour (like the little rectangle B on Pl. **13**), recalling vividly the appearance of *Diazona violacea* from the Mediterranean.

There can be no doubt then (as I find Mr. J. Hopkinson adds in a footnote to the Supplement of Alder and Hancock's 'British Tunicata,' vol. iii. p. 100, Ray Society, 1912) that *Syntethys hebridicus*, Forb. & Goods., is merely a synonym of *Diazona violacea*, Sav. The only doubt that remained was as to whether the green Hebridean form could be separated as another species of the same genus, but an examination of the detailed structure of the ascidiozooid in colonies from both the Mediterranean and the Hebrides has satisfied me that there are no grounds for such a separation. I have now before me the following material in alcohol :—

Colony from Naples, 1890, colour mauve;
Colony from Naples, 1912, colour dull greyish green ;
Colony from Plymouth (large ascidiozooids), colour mauve;
Ditto (basal part, with small ascidiozooids), colour greyish green ;
Colony from Mull, 1885, colour mauve ;
Colony from Hebrides ('Runa'), 1912, colour violet ;

and although these specimens differ considerably in colour and appearance, they all agree in structure. The branchial and atrial apertures are, I believe, always 6-lobed, although in contracted or badly preserved specimens it may be difficult to demonstrate the lobes. I give (Pl. **14**. figs. 1 & 2) drawings of 6-lobed apertures in both test and mantle from my Hebridean specimen. Then in regard to the structure of the branchial sac every specimen shows a wide range of variation in the number of stigmata in a mesh and in the exact condition of the internal longitudinal bars, as I shall show in detail below.

It is stated in the second volume of 'The British Tunicata' by Alder and Hancock, edited by Hopkinson (Ray Society, 1906), that *Diazona* has "the intersections of the meshes papillated" (p. 159) ; and in *D. hebridica* stout papillæ are both figured and described (p. 162) and are stated to be a

character that may enable the Hebridean to be separated from Savigny's species with "slender, pointed" papillæ. But, as a matter of fact, neither the southern nor the northern form has any papillæ at all in the branchial sac, as was explained * in my paper in 1891. As I stated then, the "hooked fleshy tubercles" (=papillæ) of Forbes and Goodsir's description can be quite satisfactorily accounted for by the corrugation of the internal longitudinal bars, the thick prominent connecting ducts which seem to project on each side where they join the bars, and the imperfect condition of the bars in some parts of the sac. When a branchial sac is first opened, in the case of most ascidiozooids, and is examined in water under a low power of the microscope, the appearance of large papillæ at the angles of the meshes is so distinct that it is difficult to realise, until the specimen has been stained, mounted, and examined in detail with a high power, that only connecting ducts and more or less irregular bars are present. There is no difficulty in understanding how it is that some previous investigators have fallen into the error of supposing that they saw large papillæ. Figs. 4 to 16 on Pl. **14** illustrate these remarks. Figs. 5, 6, & 16 show corrugated internal bars forming projections, but without any true papillæ ; figs. 4, 12, 13, & 14 show connecting ducts which have not grown together to form bars, and so give a deceptive appearance of being large papillæ.

In regard to the supposed difference between the two forms in the number of stigmata in a mesh, the range of variation is great (see figs. 10 to 15) and is much the same in all the specimens I have examined, as is shown by the following note :—

Naples (1912)	specimen has	2–3	stigmata in a mesh.
Mull (1885)	,,	1–4	,,
'Runa' (1912)	,,	1–3	,,
Plymouth	,,	1–3	,,

Probably some parts of each of the branchial sacs could be found showing the four stigmata in a mesh described by Savigny, and certainly many parts show the single stigmata referred to by Forbes and Goodsir. The stigmata are found to differ also very greatly in size and shape in different parts of the same sac (fig. 9).

The distinctions depending upon lines of white pigmentation on the ascidiozooids referred to by Forbes and Goodsir, Giard, Lahille, and others are so slight and so unreliable that in the absence of any real structural differences they need not be considered. Lahille regards them as at most serving to separate the type and two varieties which he proposes to call :—

(Type) *D. violacea*, Sav.—(Mediterranean.)
(Variety 1) *D. hebridica-violacea*, Forb.—(Hebridean seas.)
(Variety 2) *D. intacta-violacea*, Lah.—(Banyuls.)

* And was also shown by Lahille in the case of the Mediterranean form (Recher. sur les Tuniciers, Toulouse, 1890).

According to this nomenclature our 'Runa' specimens would fall into the first variety, the name of which I would prefer to write as *Diazona violacea*, Savigny, variety *hebridica*, Forb. & Goods.

Turning now to the colour of the colony as a whole, and to the change of colour that has been described, we find that the curious point about the colour of this animal is that, whereas British specimens are green when alive and become violet when preserved in spirit, Mediterranean specimens are apparently sometimes violet and sometimes green, and the latter do not always change their colour when treated with alcohol. Professor R. Dohrn, Director of the Zoological Station at Naples, has kindly sent me a pale green *Diazona violacea* preserved in alcohol, and he informs me that both green and violet-coloured specimens have been obtained from time to time in the neighbourhood of Naples. He states that it has not been noticed in their preservation department at the Zoological Station that any change of colour takes place on adding alcohol ; but he adds in his letter that he remembers to have noticed that the green *Diazona* becomes of a bluish colour when injured *.

It is remarkable that my large violet-coloured 'Runa' colony still continues after four months' preservation to give out the green pigment, as three successive changes of spirit have now been coloured by it. The violet pigment of the preserved specimen, however, seems to be insoluble, as fragments so coloured have been kept in absolute alcohol, in chloroform, in bisulphide of carbon, and in xylol for weeks without showing any change in tint.

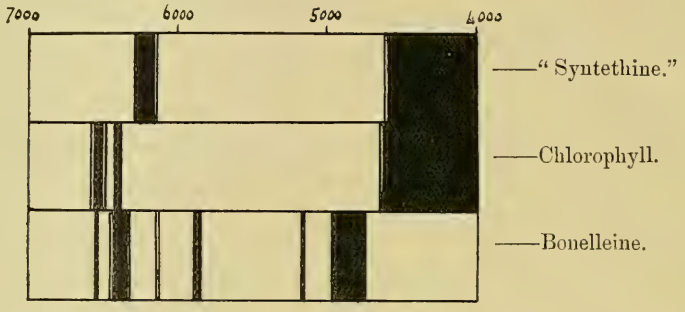
The brilliant green solution which this Hebridean specimen has given with alcohol has been examined spectroscopically for me by Dr. Alfred Holt, Reader in Physical Chemistry in the University of Liverpool, and he has shown me that the pigment is not chlorophyll—as might have been supposed at first—but has a characteristic absorption band in the orange intermediate in position between the band given by sodium and that of chlorophyll. The position of this band in Ångstrom units is 6200; while chlorophyll gives a band at 6550, and bonelleine, described by Sorby in 1875 from the green Gephyrean worm *Bonellia viridis*, has a corresponding band in the orange at 6430. In chlorophyll there is much greater absorption at the blue end of the spectrum, and in "syntethine," as observed, there is almost an identical effect, while in bonelleine there is a well-marked band in the blue and relatively less absorption in the indigo and violet.

The "Syntethys" pigment (we do not know yet whether it can be obtained also from the *Diazona* that is violet when living) does not go purple with acids, and therefore cannot be bonelleine. Acids or alkalies turn it some-

* F. Lahille states (1890) that specimens at Banyuls kept in aquaria degenerate, and that their pale yellowish colour becomes bluish or violet.

what yellowish, and the colour is not restored on neutralisation. No distinct bands are shown in acids or alkaline solutions. Possibly our substance and bonelleine belong to the same natural group (what Sorby called a "genus") of pigments. Dr. Holt has kindly supplied me with a diagram (fig. 2)

Fig. 2.



showing the spectrum of the new pigment—to which the name "syntethine" may be appropriately applied—compared with those of bonelleine and of chlorophyll.

The violet of the large 'Runa' colony in its present condition is the complementary colour to the green which has been dissolved out of it, so that when the colony is submerged in the solution it appears to lose at once its brilliant colour and become dull grey. The question then arises—was the violet pigment present, masked by the green, when the animal was living; or has chemical action taken place, possibly due to dehydration by the alcohol, which, while dissolving out the green, caused the precipitation of another previously less conspicuous pigment in the present opaque violet form; or, are the green and the violet two forms of the same pigment partly dissolved out in the green form and partly precipitated as the insoluble violet?

Histologically the violet colour is due to minute opaque granules closely placed in the spherical pigment cells with which the test is found to be crowded (see Pl. **14**. fig. 3). Similar opaque green pigment cells are visible in abundance in the test of the 'Runa' specimens which are preserved in formalin (Pl. **14**. fig. 1).

It is evident that the little we know of this pigment does not yet throw any light upon the curious colour changes in *Diazona*, and fails as completely as the structural characters to afford any evidence of specific distinction between the Mediterranean and the Hebridean forms. "Nimium ne crede colori" may be a sound aphorism for the systematist in some groups, but still colour does mean something and may mean a great deal from the physiological point of view.

The colony of *Diazona* is known to undergo remarkable degenerative and

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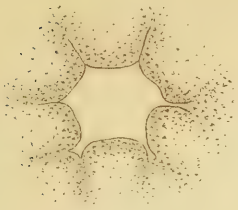
DIAZONA



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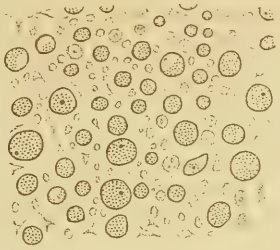

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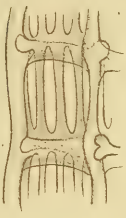

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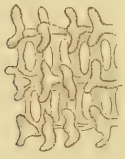

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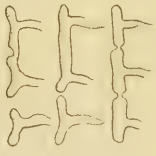

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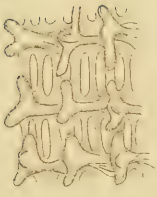

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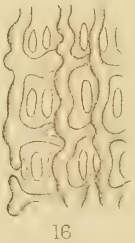

16

W. A. Herdman del.

West, Newman lith. & imp.

DIAZONA.

regenerative changes in its life-history, involving, no doubt, profound alterations of the metabolism; and it occurs to me as possible that, if green is the normal colour when in full vitality, those Mediterranean specimens which are described as violet when alive may be in the state preparatory to regeneration when the abnormal life-processes may have caused a chemical change in the pigment similar to that produced in the green Hebridean forms when treated with alcohol.

EXPLANATION OF THE PLATES.

Plate 13.

Fig. 1. Colony of *Diazona violacea*, dredged in the Outer Hebrides, Aug. 1912; about one-half natural size. From a water-colour sketch of the living animal.

2. From Forbes and Goodsir's coloured figure of "*Syntethys hebridicus*," published in 1851; slightly reduced.

A. To show the mauve colour of some preserved specimens.

B. To show the violet colour of the large 'Runa' specimen (fig. 1) after preservation in alcohol.

Plate 14.

Fig. 1. Branchial aperture in the test of a Hebridean (green) *Diazona*, to show the 6 lobes; slightly enlarged.

2. Branchial aperture in the mantle of the same Hebridean *Diazona*, to show the 6 lobes; slightly enlarged.

3. Part of the test of a violet *Diazona*, to show the conspicuous pigment cells and the colourless test cells; high power.

Figs. 4 to 8. From a Naples specimen, to show the variations in the character of the branchial sac. Fig. 8 shows the epithelium on a bar opposite the junction with a connecting duct.

9 & 10. From a Mull specimen (Duke of Argyll, 1885), showing variations in numbers and sizes of stigmata.

11 to 13. From a Plymouth specimen, showing variations in the conditions of the bars.

14 to 16. From a Hebridean ('Runa,' 1912) specimen, showing variations in the characters of the branchial sac.

With the exception of fig. 8, which is a high-power view, figs. 4 to 16 are all of the same magnification, about 40 diameters.

Addendum.

On the Amphipoda, &c., collected from the 'Runa,' by Alfred O. Walker, F.L.S.; and List of the Echinodermata collected from the 'Runa,' by H. C. Chadwick, A.L.S.

At the meeting of the Society, on December 5th, when the preceding paper was read, Mr. A. O. Walker made some remarks in regard to the Crustacea collected, and read a list of the Amphipoda and Isopoda which he

had identified and which he afterwards sent to me for incorporation in this paper. It is as follows :—

**Aristias neglectus*, Hansen.
Perrierella Audouiniana (Sp. Bate).
Tryphosa Sarsii (Bonnier).
Ampelisca tenuicornis, Lillj.
„ *spinipes*, Boeck (young).
Haploöps tubicola, Lillj.
Amphilochus manudens, Sp. Bate.
Leucothoë spinicarpa (Abildg.).
Cressa dubia, Sp. Bate.
Stenothoë marina (Sp. Bate).
Colomastix pusilla, Grube.
**Panoplœa Eblanæ* (Sp. Bate).
Neopleustes bicuspis (Kröyer).
**Sympleustes latipes* (M. Sars).
Epimeria cornigera (Fabr.).
Melita obtusata (Montagu).
Maera Othonis (M.-Edwards).
**Photis Reinhardi*, Kr.
Eurystheus maculatus (Johnston).
Leptocheirus pectinatus (Norman).
[? = *L. pilosus*, Zadd.] †
Jassa pusilla (G. O. Sars).
Erichthonius brasiliensis (Dana).
Proto pedata (Müller).
Astacilla longicornis (Sowerby).
Janira maculosa, Leach.

The four species marked with a star have not been found by us in the Irish Sea area.

This is probably the most northerly record of *Colomastix pusilla*, Grube. It was found on the Ceylon Pearl Banks in 1902 (see Herdman's Report, Royal Society, Part II. p. 299).

Panoplœa Eblanæ (Sp. Bate) is a Mediterranean species. The most northerly record hitherto is that of the type described by Spence Bate from specimens taken from the branchial cavities of *Rhizostoma* from Dublin Bay. It appears to be very rare in British seas, as it does not even occur in the magnificent collection presented to the British Museum by Canon A. M. Norman, as I am informed by Dr. Calman, who identified this species.

Mr. H. C. Chadwick, A.L.S., has identified the Echinodermata of the cruise as follows :—

Holothuria tremula, Gunner.
Phyllophorus Drummondi (Thomps.).
Antedon Milleri (Wyv. Thom.).
„ *phalangium* (J. Müll.).
„ *bifida* (Penn.).
Luidia ciliaris (Phil.).
„ *Sarsi*, Düb. & Kor.
Palmipes placenta (Penn.).
Solaster papposus, Fabr.
„ *endeca*, Linn.
Asterias Murrayi, Bell.
Asterias Muelleri (Sars).
„ *rubens*, Linn.
Porania pulvillus (O. F. Müll.).
Ophiura ciliaris (Linn.).
„ *albida*, Forb.
Amphiura Chiajii, Forb.
Ophiopholis aculeata (Linn.).
Asteronyx Loveni, M. & T.
Spatangus purpureus, O. F. Müll.
Brissopsis lyrifera, Forb.
Echinus esculentus (Linn.).

The Hebridean specimens of *Echinus esculentus*, compared with those commonly found at the Isle of Man, are uniformly higher and more pentagonal in shape, and have the primary tubercles on both ambulacral and interambulacral plates smaller in size and number, and the secondary tubercles much more feebly developed. The arrangement of the pores on the ambulacral plates is also slightly different in the two cases.

† These two are considered distinct by Mrs. Sexton (Proc. Zool. Soc. Lond. 1911, p. 561)